

TECHNIQUE OF DEVELOPING A DRYING PROCESS FOR SMALL STOCK

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TECHNIQUE OF DEVELOPING A DRYING PROCESS

FOR SMALL STOCK

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In drying small pieces of wood, the handling cost is an important factor. One possible drying procedure is to dump the pieces loosely into a crib and force air through the voids. This process has been used to some extent and, in general, has proven to be fairly satisfactory.

Recently the opinion of the Forest Products Laboratory was asked concerning the drying procedure for cocobolo handles. Cocobolo is a Central American wood that has long been used in the cutlery trade for knife handles. The principal commercial sources are Costa Rica, Nicaragua, and Panama. It has a dark color, fine texture, and dense structure and contains an oil that tends to waterproof the wood and keep it in shape after manufacture. Prolonged or repeated immersing in soapy water is reported to have little effect on the wood except to darken its color, an important advantage in kitchen and butcher knives. It is also used for small tool handles, brush backs, and in musical and scientific instruments.

The crib method of drying was suggested, but no data were available showing frictional and other losses in forcing air through such a load. The problem was considered to be of sufficient general interest to justify a small amount of work to determine the pressure drop and air velocity through crib loads of various lengths in the direction of air travel.

Experimental Procedure

The blocks used were 21/32 by 1-1/32 by 4-3/4 inches in size and were dumped loosely into a duct approximately 2 by 2 feet in cross section. A one-half inch mesh screen at each end retained the blocks in a vertical position and the distance between the screens represented the length of air travel through the load. This distance was varied from 1 to 6 feet in one-half foot intervals, and for each loading, fan speeds of 220, 440, 660, 880, and 1,170 revolutions per minute were used to obtain various pressure drops across the load. Readings of the drop in pressure across the load were obtained by means of two static pressure

tubes connected to a micromanometer. Air volumes and air velocities were obtained from anemometer readings taken in a connecting duct. These were adjusted according to cross-sectional areas to give the velocity of the air as it entered the load and then further adjusted according to the percentage of voids to obtain the average air velocities within the load. The percentages of voids were obtained by counting the number of pieces in each crib load.

Figure 1 is a photograph of a crib load of blocks as located in the test duct.

Results

The results are shown graphically in figures 2 and 3.

The curves of figure 2 show the effect of length of load on fan delivery and pressure head at several fan speeds. The shape of the curves indicates an entrance loss and, therefore, relatively big losses for short loads. The limitations of the fan to increase the pressure head against added resistances are shown also by the flattening of the pressure curves as the length of air travel increases.

The single curve in figure 3 shows the amount of voids as a function of length of air travel. The change in the amount of voids was due to the fact that the pieces against the screens were supported in such a way as to increase the voids in those areas, but as the length of load increased this effect decreased and for long loads the percentage of voids was practically constant at approximately 55 percent.

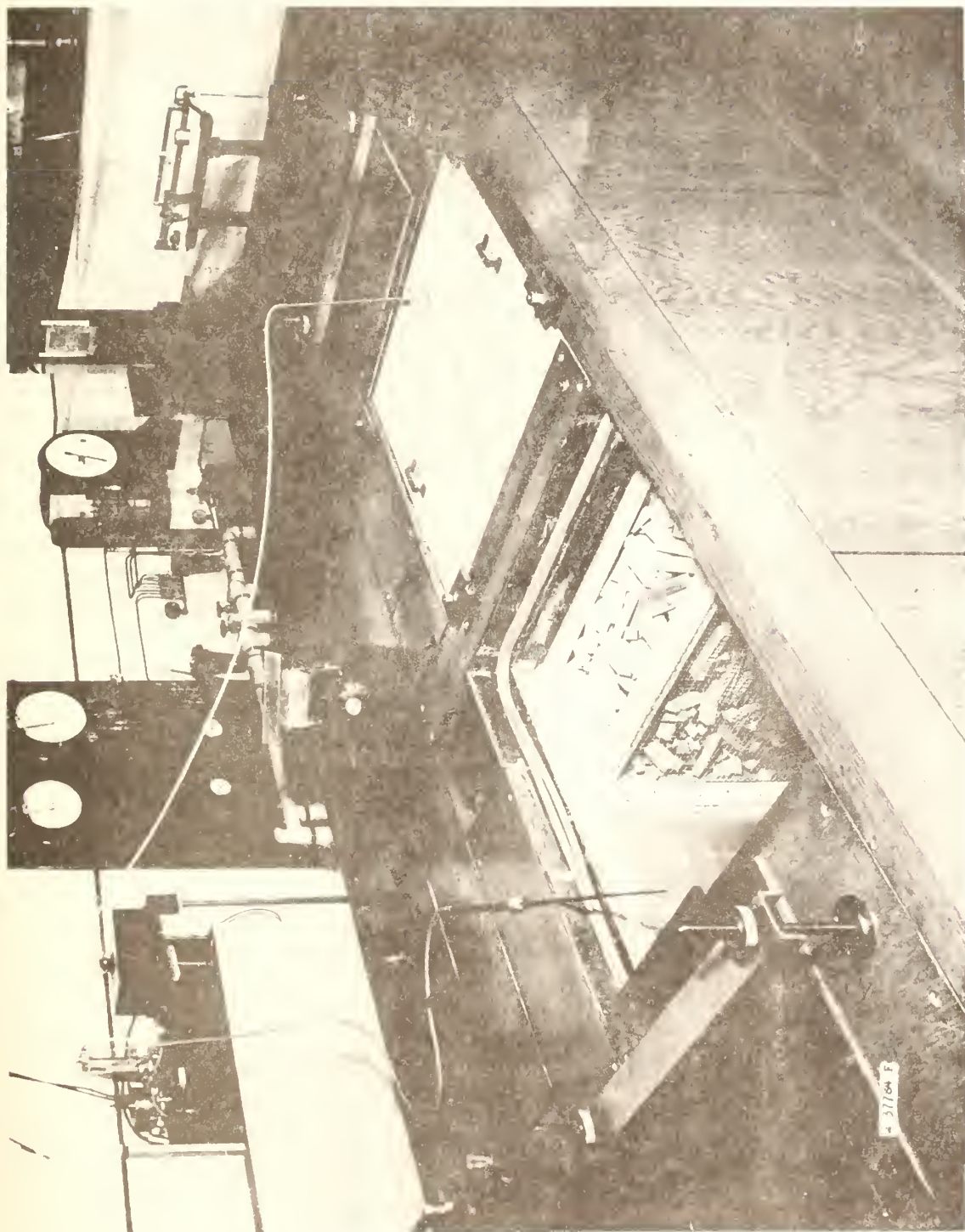
The curves of figure 3 show the effect of length of load on air velocity for a series of pressure drops between 0.1 and 1.0 inch of water. The curves on the left show the velocity of the air in the duct before entering the load and those on the right are the same values adjusted according to the percentage of voids to show the average velocity within the load.

Figure 3 indicates that a considerable amount of air volume will pass through a crib load of small blocks even under small pressure drops across the load. It is therefore concluded that the pressure drops obtainable with a disk fan are satisfactory provided the resistance of the system is not too great and that the kiln and baffles are sufficiently tight to prevent excessive leakage.

Under the same pressure drop, the air delivery through a 5-foot load was approximately one-half of that through a 1-foot load. The flattening of the curves indicates, however, that the length of load could be increased greater than 5 feet with relatively small decreases in air delivery.

Figure 1.--A crib load of blocks in the test duct.

The return duct on the opposite side
is used for air measurements.



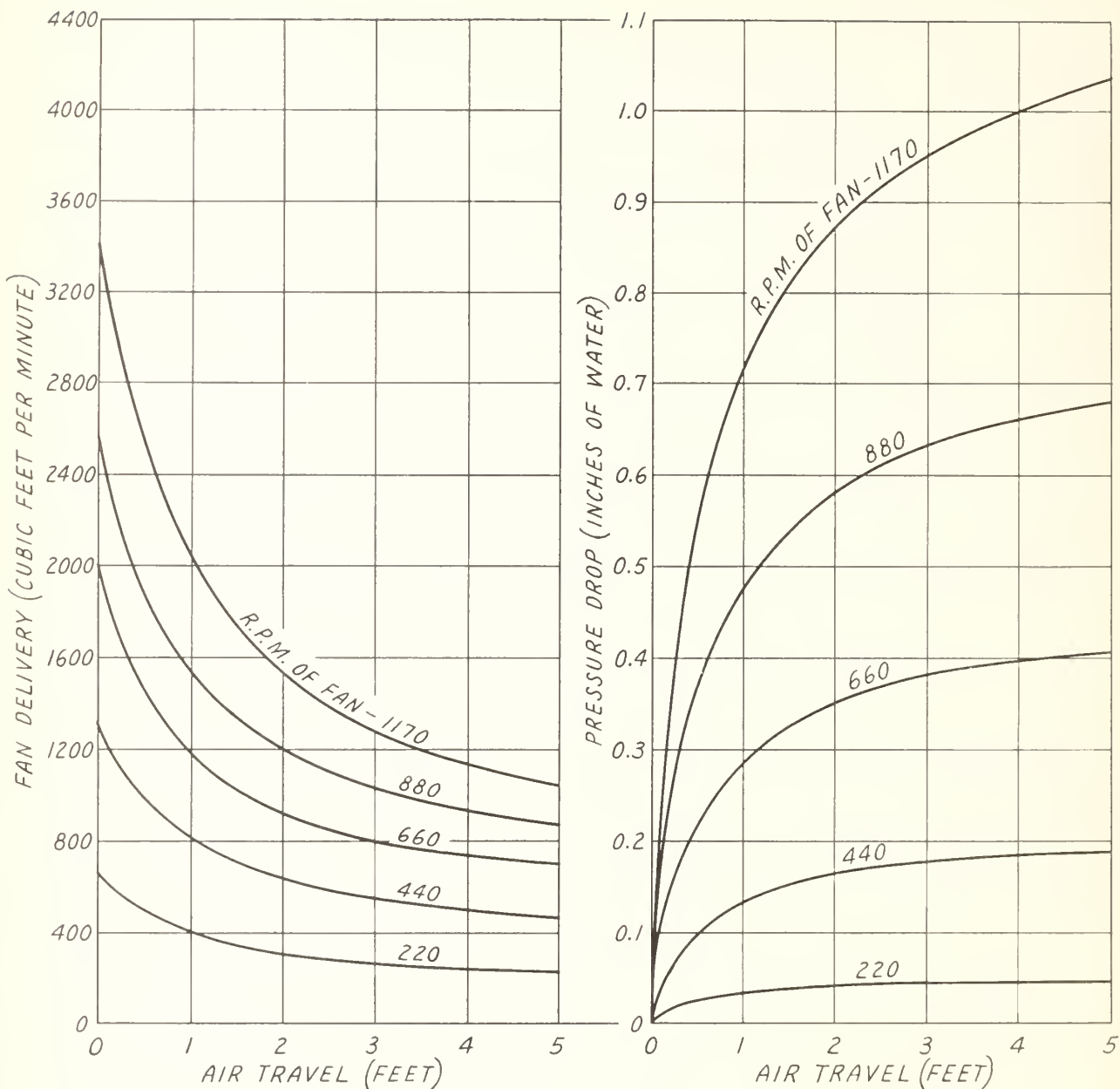


FIG. 2
 PERFORMANCE OF 24-INCH DISK FAN
 WHEN DELIVERING AIR THROUGH LOOSE PILE OF $\frac{21}{32}$ BY $1\frac{1}{32}$ BY $4\frac{3}{4}$ -INCH BLOCKS

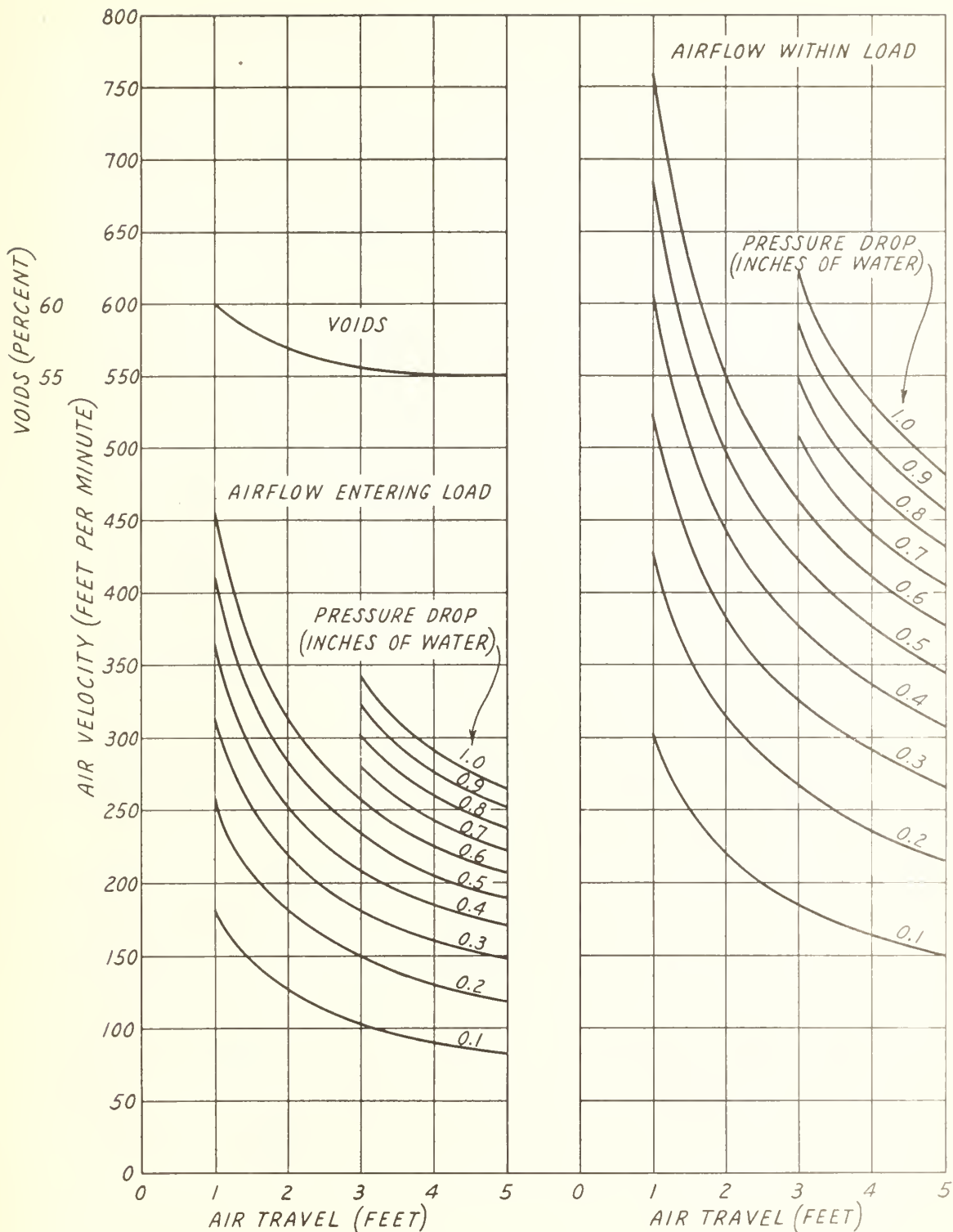


FIG. 3
AIR VELOCITY THROUGH LOOSE PILE OF $\frac{21}{32}$ BY $1\frac{1}{32}$ BY $4\frac{3}{4}$ -INCH BLOCKS
UNDER VARIOUS LENGTHS OF LOAD AND PRESSURE DROPS ACROSS LOAD

Calculation of Air Needs Based on Assumed Drying

Conditions

The Laboratory has practically no information concerning proper schedules for cocobolo. End checking and color must be considered. The schedule in table 1 is believed to be conservative, but is given mainly as a basis for calculating the air needs:

Table 1.--Kiln drying schedule

Stage of drying	Moisture content	Temperature	Relative humidity	Theoretical drying time
	Percent	° F.	Percent	Hours
1	35 to 25	120	80	17
2	25 to 15	130	60	28
3	15 to 3	140	10	69
Total.....	35 to 3			114

A final moisture content of 3 percent is given because, from reports, a low moisture content is desirable from a manufacturing standpoint. To obtain a moisture content lower than this in a reasonable drying time would require temperatures above 140° F.

It is believed that the drying rate of cocobolo is certainly not faster than that of oak, and, because of its greater density, cocobolo may dry even slower. The drying rate of oak, however, was used in calculating the time needed for each stage of drying under the schedule.

In order to compute air needs for the various stages of drying, the oven-dry weight of cocobolo was assumed to be 60 pounds per cubic foot. Within 1 square foot of crib 5 feet long having 55 percent voids, the volume of wood would be approximately 5 x 0.45 or 2.25 cubic feet, and the weight would be 2.25 x 60 or 135 pounds. The total moisture loss per minute during each stage of drying is given in table 2.

Table 2.--Average drying rate

Stage of drying	Moisture content loss	Oven-dry weight of wood	Moisture loss	Drying time	Average moisture loss per minute
	<u>Percent</u>	<u>Pounds</u>	<u>Pounds</u>	<u>Minutes</u>	<u>Pound</u>
1	10	135	13.5	1,020	0.0132
2	10	135	13.5	1,680	.0080
3	12	135	16.2	4,140	.0039

A second assumption must be made regarding the proper temperature drop across the load to avoid an excessive drying lag on the leaving air side. A 4-degree temperature drop is assumed to be satisfactory in this respect for each of the three stages of drying.

At the temperatures and relative humidities given in the schedule, the first stage of drying requires 61,000 cubic feet of air to evaporate 1 pound of water with a 1° F. temperature drop across the load; the second stage, 62,000 cubic feet; and the third stage, 63,000 cubic feet. The air requirements for each stage are computed in table 3 by multiplying by the average amount of moisture evaporated per minute and dividing by the 4-degree selected temperature drop.

Table 3.--Air requirements

Stage of drying	Air volume through 1 square foot of cross section of crib
	<u>Cubic feet per minute</u>
1	202
2	124
3	62

As 1 square foot of crib area was taken as a basis, these values represent also the velocity of the entering air.

Referring again to the left hand series of curves in figure 3, an entering air velocity of 202 feet per minute with a 5-foot air travel requires a pressure drop across the load of practically 0.6 inch of water. Table 4 shows the pressure drop requirements for each of the three stages of drying with a 5-foot air travel.

Table 4.--Pressure drop requirements

Stage of drying	:	Entering air requirements	:	Pressure drop requirements
	:	<u>Feet per minute</u>	:	<u>Inch of water</u>
1	:	202	:	0.58
2	:	124	:	.21
3	:	62	:	.07

The computed drying periods are based on an infinite air velocity and are the minimum under the assumed drying characteristics of the wood. They do not take into account the lag in drying due to the temperature drop across the load, and therefore, the actual average drying time for the load may be somewhat greater than those shown. For the same reason, air velocities higher than those computed will result in temperature drops less than 4 degrees and will bring the average drying time of the load more nearly to that computed.

PUBLICATION LISTS ISSUED BY THE FOREST PRODUCTS LABORATORY

The following lists of publications based on research at the Forest Products Laboratory (Madison 5, Wis.) are obtainable on request:

Boxing and Crating

Building Construction Subjects

Chemistry of Wood and Derived Products

Fungus Defects in Forest Products

Furniture Manufacturers, Woodworkers, and
Teachers of Wood Shop Practice

Glue and Plywood

Logging, Manufacture, and Utilization of
Timber, Lumber, and Other Wood Products

Mechanical Properties and Structural Uses
of Wood and Wood Products

Pulp and Paper

Seasoning of Wood

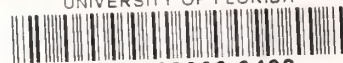
Structure and Identification of Wood

Wood Finishing Subjects

Wood Preservation

Since Forest Products Laboratory publications are so varied in subject no single big list is issued. Instead a list is made up for each Laboratory division as shown above. Twice a year, a list is made up showing new reports for the previous 6 months. This is the only item sent regularly to the Laboratory's mailing list. Anyone who has asked for and received the proper subject lists and who has had his name placed on the mailing list can keep up to date on Forest Products Laboratory publications. There is no charge for single copies of any of the reports.

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